Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM
ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

The Influence of the Use of Fluid and Thermodynamics KIT on Conceptual Shifts in Dynamic Fluid Material

Dewi Astuti Saromeng[1*], Asri Arbie[2], Abdul Haris Odja[2]

[1]Department of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo, Gorontalo, Indonesia
[2]Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo, Gorontalo, Indonesia
[*]e-mail: dewiastutisaromeng@gmail.com

Received: March 3, 2026. Accepted: April 7, 2026. Published: June 2, 2026

Abstract: Physics learning often causes students to experience misconceptions, especially in fluid dynamics material. This study aims to analyze the effect of the use of the Fluid and Thermodynamics KIT on the shift in students' conceptions. This study used a quantitative approach with a one–group pretest–posttest design involving three experimental classes (replications 1 and 2) and a total of 90 students. The instrument used was a three-tier test to identify conception categories. Data analysis techniques were carried out using descriptive statistical analysis in the form of a percentage of conception shifts classified into positive shifts (↑), negative (↓), and no effect (O). The results showed that the Fluid and Thermodynamics KIT was characterised by positive conception shifts across all classes. The highest percentage of positive shifts was in the experimental class (73%), followed by replication 2 (56.33%) and replication 1 (53%). The negative shifts were 30%, 25.67%, and 15.67%, respectively, while the no-effect category was 17%, 21.33%, and 28%, respectively, in the experimental class, replication 1, and replication 2. These findings indicate that the Fluid and Thermodynamics KIT is effective in facilitating conceptual reconstruction and improving students' understanding of fluid dynamics.

Keywords: Conceptual Shifts; Dynamic Fluids; Fluid and Thermodynamics KIT.

Introduction

Physics is a branch of science that studies the interactions of energy, matter, space, and time, and specifically focuses on explaining the basic mechanisms by which phenomena occur [1]. Learning physics at the high school level requires students not only to understand theoretical concepts but also to connect them to real-world phenomena. However, many students still struggle with abstract material, including fluid dynamics, which covers pressure, flow rate, continuity, and Bernoulli's law. The inability to understand the relationships between physical quantities often leads students to rely on memorizing formulas without understanding their physical meaning [2].

These difficulties often lead to misconceptions, namely, students' understanding that does not align with actual scientific concepts. Misconceptions that go uncorrected can become a serious obstacle to students' understanding of more complex physics concepts [3]. Misconceptions among students in Physics subjects must be addressed immediately because they can hinder understanding of scientific concepts [4]. Students who hold incorrect or inaccurate conceptions will have unstable knowledge; even when they can answer questions correctly, the reasoning behind their answers is often conceptually incorrect. In the context of learning fluid dynamics, misconceptions can arise in various aspects; for example, students may assume that pressure depends only on fluid volume or that greater flow velocity always results in higher pressure, even though Bernoulli's law shows the opposite relationship [5].

Misconceptions are part of how learners construct knowledge. Understanding is formed through the processes of assimilation and accommodation of new experiences. Therefore, learners need to actively engage in observation, experimentation, and exploration of physical phenomena so that the knowledge acquired aligns with scientific concepts. Without these experiences, the resulting conceptions often deviate [6].

Physics learning in schools is still often theoretical and teacher-centered. Teachers more frequently use lectures and practice exercises without providing adequate experimental experiences. As a result, students find it difficult to visualize abstract concepts such as pressure, fluid energy, and the relationship between flow speed and cross-sectional area [7]. In such situations, learning media that can provide concrete experiences become very important. One effective medium to help students understand fluid concepts is the Fluid and Thermodynamics KIT.

The Fluid and Thermodynamics KIT is a laboratory tool that facilitates experiment-based learning, allowing students to directly observe phenomena such as fluid flow in pipes, the Venturi effect, and the application of Bernoulli's principle. Emphasize that experimental learning can enhance conceptual understanding and learning engagement. Thus, the use of the KIT helps students construct accurate concepts through direct observation and experience, in accordance with the principles of constructivism [8].

How to Cite:
D. A. Saromeng, A. Arbie, and A. H. Odja, "The influence of the use of fluid and thermodynamics KIT on conceptual shifts in dynamic fluid material," *Jurnal Pijar MIPA*, vol. 21, no. 3, pp. 492–497, 2026. https://doi.org/10.29303/jpm.v21i3.11717

The use of Fluid and Thermodynamics KITs also plays an important role in enhancing students' conceptual understanding. Conceptual improvement is not only about correcting errors but also guides students to replace outdated concepts with scientifically accurate ones through reflection and empirical verification. Learning experiences that create cognitive conflict are an effective strategy to promote conceptual change [9]. When the results of an experiment do not align with initial predictions, students are prompted to reassess their previous understanding and adjust it to the correct concept. In this context, Fluid and Thermodynamics KITs provide exploratory experiences that allow students to build knowledge through direct observation, thereby strengthening their conceptual reconstruction.

Fluid and Thermodynamics KIT makes this possible by presenting real phenomena that can be observed directly. For example, in experiments on Bernoulli's law, learners can see that fluids flow faster in narrow areas, resulting in reduced pressure, an outcome that often contradicts learners' initial assumptions [10]. Experiences like this are crucial in promoting conceptual change, that is, the shift from misconceptions to scientific understanding.

Several studies have demonstrated the effectiveness of using Fluid and Thermodynamics KITs in physics learning. The field of fluid mechanics found that experimental activities using simple tools can significantly enhance students' conceptual understanding [7]. Reducing misconceptions through an experimental approach can meaningfully improve understanding after learning interventions [3]. These findings suggest that laboratory activities play an important role in helping students develop more stable and scientific concepts.

However, there is still a gap in the research on the effectiveness of using Fluid and Thermodynamics Kits, particularly regarding students' conceptual shifts. Most previous studies have primarily emphasized improving learning outcomes or cognitive scores, rather than the transformation of students' conceptual categories from Lack of Concept Understanding (LCU) or Misconception (M) to Understanding the Concept (UC). Conceptual shifts, however, serve as a deeper indicator than mere grade improvements, as they reflect meaningful changes in students' cognitive structures [11].

This research was conducted at SMA Negeri 1 Bintauna and involved three classes: the experimental class and the replications 1 and 2. All three classes received instructional treatment using the Fluid and Thermodynamics KIT with a focus on dynamic fluid material. Data were obtained through a three-tier test in the form of multiple-choice questions designed to assess students' levels of understanding and types of misconceptions before and after instruction [10]. The analytical technique used was frequency analysis of concept categories: Understanding (UC), Misconception (M), Lack of Concept Understanding (LCU), and Correct Guessing (CG).

This study aims to determine the extent to which the Fluid and Thermodynamics KIT can shape students' conceptual categories toward a more scientific understanding. The new conceptions that align more closely with the principles of physics are evident in the posttest results, indicating that experiential learning effectively reinforces students' knowledge structures. Thus, the conceptual changes observed in the posttest serve as a primary indicator of the effectiveness of implementing the Fluid and Thermodynamics KIT in learning.

Furthermore, this research is expected to contribute to the development of physics learning strategies in schools, particularly in terms of utilizing experimental media as a means to enhance students' conceptual understanding. Physics teachers can use the findings of this study to design more meaningful learning experiences that integrate theory, practice, and conceptual reflection. In addition, the results of this research are expected to inform educational policymakers in providing simple laboratory facilities, such as fluid and thermodynamics kits, that support inquiry-based and constructivist learning.

Therefore, this study not only focuses on enhancing learning outcomes but also on fundamental changes in students' understanding of physics concepts, as indicated by their response patterns. The shift from misconceptions to scientific understanding provides evidence that well-designed instruction utilizing the Fluid and Thermodynamics KIT can serve as a strategic approach to improving the quality of physics education in schools.

Research Methods

This study employs an experimental one-group pretest-posttest design with multiple-choice questions to examine the effect of using Fluid and Thermodynamics KITs on students' conceptual shifts in dynamic fluids. Students were first given a pretest (O_1) to identify their initial conceptions, then participated in KIT-based learning that emphasized experimental activities and observation of fluid phenomena (X). After the learning process, a posttest (O_2) was administered to assess the conceptual changes that occurred. This design was chosen because it can illustrate conceptual changes by comparing the initial and final conditions within the same group [12].

The study was conducted at SMA Negeri 1 Bintauna, North Bolaang Mongondow Regency, from August to October 2024. The research sample was obtained using a total sampling technique, which included all students of grade XI MIPA in the 2024/2025 academic year, totalling 90 students, divided into three classes: XI MIPA 1 (experimental class) with 30 students, XI MIPA 2 (replication 1) with 30 students, and XI MIPA 3 (replication 2) with 30 students. Total sampling was chosen because the number of students was relatively small and homogeneous, thereby enhancing external validity [11]. The research subjects were grade XI MIPA students, while the research object was the conceptual shifts following lessons using the Fluid and Thermodynamics KIT.

The research instrument consists of a diagnostic three-tier test in the form of multiple-choice questions used to identify students' understanding and misconceptions [13]. This test includes options for conceptual answers, reasoning for the answers, and confidence levels, allowing conceptions to be classified into four categories: Conceptual Understanding (CU), Misconception (M), Lack of Conceptual Understanding (LCU), and Correct Guess (CG) [14]. The instrument comprises 10 items measuring indicators of hydrostatic pressure, the principle of continuity, Bernoulli's law, and fluid discharge.

The validity of the instruments and learning devices was tested through two stages. Content validity for the three-tier test multiple-choice instruments was established through Expert Judgment by three physics education lecturers, who evaluated the alignment of the test items with the competency indicators [15]. Furthermore, the learning devices, including the syllabus, lesson plans, student worksheets, teaching materials, and three-tier tests, were validated by subject-matter experts and physics education practitioners to ensure their feasibility, clarity, and alignment with the learning objectives. Reliability testing using Cronbach's Alpha yielded a value of r_{11} = 0.82, which falls into the very high category [16], the instruments were deemed consistent and suitable for use in the study.

Data analysis involved calculating changes in conception for each category from the pretest to the posttest. Conceptual shifts were classified as follows:

1. Positive response (↑), indicating a shift toward a higher level of understanding, for example, from Misconception (M) to Guessing (CG), from Misconception (M) to Lack of Conceptual Understanding (LCU), from CG to LCU, or from LCU to Conceptual Understanding (CU);
2. Negative response (↓), if there is a shift from a higher category to a lower category, for example, from Conceptual Understanding (CU) to LCU, CG, and M, from LCU to CG and M, or from CG to M;
3. No effect (O), if the conception category remains the same.

In addition to using arrow symbols, student responses on the three-tier diagnostic test are also expressed as three-letter codes indicating the correctness of the answer, the accuracy of the reasoning, and the level of confidence. The first letter indicates the correctness of the concept answer (B = Correct, S = Incorrect), the second letter indicates the correctness of the reasoning or explanation (B = Correct, S = Incorrect), while the third letter indicates the student's level of confidence in their answer (Y = Confident, T = Not Confident) [17]. An explanation of the meaning of each code combination is presented in Table 1.

Table 1. Answer Codes and Conception Categories of Students

No.	Answer Code	Concept Category	Description
1.	BBY	Conceptual Understanding (CU)	Correct answer, the reason for its correctness, and confidence in the choice
2.	BSY	Misconception (M)	The answer is correct, the reasoning is incorrect, and confident in the choice.
3.	SBY	Misconception (M)	Wrong answer, correct reasoning, and confidence in the choice.
4.	SSY	Misconception (M)	Wrong answer, incorrect reasoning, and confidence in the choice.
5.	BBT	Correct Guess (CG)	The answer and the reasoning are correct, but there is uncertainty about the choice.
6.	BST	Lack of Conceptual Understanding (LCU)	Correct answer, incorrect reasoning, and uncertainty about the choice.
7.	SBT	Lack of Conceptual Understanding (LCU)	Incorrect answer, correct reasoning, and uncertainty about the choice.
8.	SST	Lack of Conceptual Understanding (LCU)	Incorrect answer, incorrect reasoning, and uncertainty about the choice.

The analysis in the experimental class, replication 1, and replication 2 aims to determine the effectiveness of the Fluid and Thermodynamics KIT in producing conceptual shifts among students in the topic of dynamic fluids.

Results and Discussion

This section presents the research results and discussion from the pretest and posttest data in the experimental class for replications 1 and 2. The research focuses on shifts in students' conceptions following the implementation of the Fluid and Thermodynamics KIT on dynamic fluids.

Table 2. Conceptual Transitions of the Experimental Class

Question Number	Positive Shift (↑)	Negative Shift (↓)	No effect (O)
1	23	3	4
2	21	4	5
3	27	1	2
4	22	3	5
5	18	2	10
6	18	3	9
7	23	2	5
8	19	5	6
9	17	4	9
10	21	3	6
Amount	219	30	51

Based on Table 2, the item-by-item analysis shows a dominance of upward arrow symbols (↑ = 219), indicating a shift in conception toward improvement, compared to downward arrows (↓ = 30) and no change (O = 51). The largest shift occurred in question number 3 (↑ = 27), while the smallest was in question number 9 (↑ = 17). These results indicate that the use of Fluid and Thermodynamics KIT is more effective for concepts that require direct visualization and practical experience compared to abstract concepts [18].

Overall, these results show that using a Fluid and Thermodynamics KIT combined with an inquiry-based approach is effective in boosting students' conceptual understanding. The Fluid and Thermodynamics KIT helps students experience physics phenomena in a tangible way that were previously only abstract, encouraging a shift from misconceptions, misunderstandings, or guessing toward a deeper understanding of the concepts [19].

The subsequent analysis is presented based on each indicator of mastery of dynamic fluid concepts. This presentation is intended to allow the conceptual changes occurring in students to be seen more comprehensively and to show which parts of the material have improved significantly and which still require reinforcement.

Indicator 1 (Question number 5) measures the ability to identify the basic properties of fluids. The analysis results show ↑ = 18, ↓ = 2, and O = 10. The high number of upward arrows indicates that most students improved their understanding of viscosity. However, the relatively large number of O suggests that this concept remains abstract for some students, leading them to maintain their initial answers without significant conceptual shifts [20].

Indicator 2 (Question 6) concerns understanding the basic principles of Bernoulli. The total shifts obtained are ↑ = 18, ↓ = 3, and O = 9. These results indicate that the majority of students improved their understanding after using the KIT, particularly regarding the relationships among pressure, velocity, and fluid height. Nevertheless, the relatively large O value suggests that some students still cling to their initial understanding or are not yet fully confident in the Bernoulli concept.

Indicator 3 (Questions number 4, 7, and 9) assesses the ability to apply the principles of fluid flow in pipes or channels. Overall, this indicator yielded ↑ = 47, ↓ = 15, and O = 28. This category shows a strong positive shift, indicating that the KIT is effective at reinforcing students' understanding of the relationships among pipe diameter, flow velocity, and pressure differences. Nevertheless, the relatively large O value indicates that some students did not experience conceptual change, particularly in more complex fluid flow situations.

Indicator 4 (Question number 8) measures the ability to use measuring instruments to determine the flow rate of fluids. This indicator shows ↑ = 19, ↓ = 5, and O = 6, which represents one of the best achievements. The high number of upward arrows indicates that the KIT is very helpful because students can make direct observations. This practical experience allows students to connect theory with measurement results, thereby minimizing misconceptions.

Indicator 5 (Questions number 2 and 3) relates to the ability to analyze the application of the continuity equation and Bernoulli's principle. The results obtained are ↑ = 32, ↓ = 11, and O = 17. The relatively large positive shift indicates that students are beginning to understand the relationships among pipe diameter, flow velocity, and pressure. However, the fairly dominant O value suggests that some students still experience confusion in applying Bernoulli's equation mathematically.

Indicator 6 (Questions 1 and 10) measures the ability to explain the application of dynamic fluid concepts in a closed system. This indicator shows the greatest conceptual change, namely ↑ = 35, ↓ = 11, and O = 14. The high number of upward arrows indicates that this concept is strongly supported by the use of instructional kits (KIT), particularly because students can directly observe the relationships among pipe diameter, pipe shape, flow velocity, and pressure variations. Concrete visualization is very effective in remedying misconceptions associated with this indicator.

Overall, the shift in students' conceptions was predominantly positive, indicating that the Fluid and Thermodynamics KIT is effective in enhancing understanding of both basic and complex concepts of dynamic fluids, including Bernoulli's law, the continuity equation, and flow in closed systems.

Table 3. Conception Transition of Replication Class 1

Question Number	Positive Shift (↑)	Negative Shift (↓)	No effect (O)
1	16	7	7
2	15	8	7
3	17	6	7
4	20	5	5
5	11	9	10
6	15	7	8
7	16	6	8
8	17	6	7
9	16	7	7
10	16	6	8
Amount	159	77	64

Based on the data from replication class 1, the item-by-item analysis shows that the upward arrow symbol (↑), indicating a shift in conception toward improvement, was recorded 159 times. Conversely, the downward arrow (↓) appeared 77 times, and the unchanged symbol (O) was recorded 64 times. The largest conceptual shift occurred in question number 4 (↑ = 20), while the smallest shift was observed in question number 5 (↑ = 11). These results indicate that the use of the Fluid and Thermodynamics KIT remains effective in enhancing students' conceptual understanding, although the positive shift is lower compared to the experimental class.

Table 4. Conception Transition of Replication Class 2

Question Number	Positive Shift (↑)	Negative Shift (↓)	No effect (O)
1	15	6	9
2	16	5	9
3	17	5	8
4	18	4	8
5	16	5	9
6	17	4	9
7	14	6	10
8	19	4	7
9	18	4	8
10	19	4	7
Amount	169	47	84

Based on the data from replication class 2, item analysis showed a predominance of upward arrow symbols (↑ = 169) compared to downward (↓ = 47) and unchanged (O = 84) symbols. The largest conceptual shifts occurred in questions number 8 and 10 (↑ = 19), while the smallest shift was observed in question number 7 (↑ = 14). These results indicate that learning assisted by the Fluid and Thermodynamics KIT remains effective in enhancing students' understanding. Practical experience through the KIT helps students connect real-world phenomena with theory, thereby minimizing misconceptions. Overall, the Fluid and Thermodynamics KIT is effective in improving students' conceptual understanding of dynamic fluid concepts, from basic to more complex ones, such as Bernoulli's law, the continuity equation, and flow in closed systems [21].

Conceptual change occurs when learners are dissatisfied with their initial understanding and adopt new, more logical concepts [22]. The Fluid and Thermodynamics Instructional Kit (KIT) serves as a cognitive mediator, connecting empirical experiences with scientific representations, thereby helping learners more easily understand the relationships among pressure, velocity, and fluid energy. Overall, concrete experiment-based learning supported by the KIT has been proven effective in enhancing learners' conceptual understanding of dynamic fluid material at the high school level.

Table 5. Total Conception Shifts per Class

Class	The percentage of cases of conception status increases	Percentage of cases of decreased conception status	Percentage of cases with a fixed conception status
Exp.	73	30	17
Rep. 1	53	25.67	21.33
Rep. 2	56.33	15.67	28

Overall, the entire class exhibited a dominance of positive shifts. The experimental class had the highest percentage increase in conception (73%), followed by replication class 2 (56.33%) and replication class 1 (53%). The highest percentage decrease in conception occurred in the experimental class (30%) and replication class 1 (25.67%), whereas replication class 2 had only 15.67%. Cases of unchanged conception status were relatively higher in replication class 2 (28%) compared to the experimental class (17%) and replication class 1 (21.33%).

The research findings indicate that the consistent implementation of the Fluid and Thermodynamics KIT significantly enhances students' conceptual understanding of dynamic fluid topics across all classes. The experimental class demonstrated the greatest conceptual gains, while both replication classes continued to show a similar pattern of improvement, albeit with a higher percentage of conceptual decline. Overall, these findings affirm that the KIT is effective in promoting conceptual shifts toward greater accuracy, though further refinement of teaching strategies remains necessary to achieve a more uniform impact on conceptual improvement across all classes.

These results align with research that found that one cause of misconceptions is that students too often respond to statements that mix calculations, resulting in a lack of understanding of narrative statements. The successful use of KIT in this study, which resulted in the highest positive shift in Bernoulli's law indicators, proves that visualization of phenomena can disprove students' incorrect intuitions [23]. Using media, such as teaching aids, can significantly enhance students' understanding of fluid dynamics concepts [24]. Teaching aids are anything that can be used to stimulate students' thoughts, feelings, attention, and willingness, thereby encouraging the learning process. Teaching aids are used to demonstrate concrete events to students. In other words, teaching aids help clarify abstract concepts and make them more concrete [25].

Conclusion

The research results indicate that learning assisted by the Fluid and Thermodynamics KIT effectively enhances students' understanding of dynamic fluid concepts. Positive conceptual shifts dominate nearly all questions in the experimental class, replication 1, and replication 2, with the highest increase observed in the experimental class (73%). Although there are some instances of decline and unchanged status, the use of the KIT has proven to help students connect real-world phenomena with theory, thereby minimizing misconceptions and significantly improving understanding of both basic and more complex concepts.

Author's Contribution

D.A. Saromeng: responsible for data collection, formal analysis, and writing the original draft. A. Arbie: provided overall supervision, validated the results, and performed critical reviews and editing of the manuscript. A.H. Odja: contributed to data curation, provided technical support, and assisted with the final review and editing. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

The author would like to express gratitude to Asri Arbie, the First Supervisor, and Abdul Haris, the Second Supervisor, for their guidance, direction, and valuable input throughout the research and writing of this article. Appreciation is also extended to the Principal of SMA Negeri 1 Bintauna for granting permission to conduct the research, as well as to the teachers and eleventh-grade students who actively participated in the learning activities using the Fluid and Thermodynamics KIT. The support from various parties has been an important contribution to the successful completion of this research.

References

[1] K. Rusmanto, S. S. Sitompul, and S. Mursyid, "Penggunaan metode interactive problem task and experiment berbantuan alat peraga untuk meremediasi miskonsepsi tentang fluida dinamis," *Jurnal Pendidikan dan Pembelajaran Khatulistiwa (JPPK)*, vol. 8, no. 6, 2019.

[2] P. R. A. Puri and R. Perdana, "Analisis kemampuan pemahaman konsep fisika peserta didik SMA di Bantul pada materi fluida statis dan upaya peningkatannya melalui model pembelajaran visualization auditory kinesthetic," *MAGNETON: Jurnal Inovasi Pembelajaran Fisika*, vol. 1, no. 2, 2023, doi: 10.30822/MAGNETON.V1I2.2463.

[3] J. Maknun and M. Marwiah, "Remediation of misconceptions vocational high school students on the concept of static fluids using the conceptual change model," *Journal of Technical Education and Training*, vol. 14, no. 2, 2022, doi: 10.30880/JTET.2022.14.02.005.

[4] A. Suárez, S. Kahan, and A. C. Martí, "Students' conceptual difficulties in hydrodynamics," *Physical*

Review Physics Education Research, vol. 13, no. 2, 2017.

[5] F. N. Sholihat, A. Samsudin, and M. G. Nugraha, “Identifikasi miskonsepsi dan penyebab miskonsepsi siswa menggunakan four-tier diagnostic test pada sub-materi fluida dinamik: Azas kontinuitas,” *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, vol. 3, no. 2, pp. 175–180, 2017.

[6] J. Piaget, *The Psychology of the Child*. New York, NY, USA: Basic Books, 1972.

[7] E. Y. Pasaribu, “Perbandingan hasil belajar peserta didik melalui metode ceramah dan think pair share (TPS) pada materi listrik statis di kelas XII SMAN 14 Kota Jambi,” in *Proc. Seminar Nasional Teknologi dan Multidisiplin Ilmu (SEMNASTEKMU)*, vol. 5, no. 1, 2025, doi: 10.51903/CSX37R56.

[8] M. Alam, M. Rahman, and R. Sarker, “Effectiveness of experiment based learning on students’ conceptual understanding of fluid mechanics,” *International Journal of Science and Research*, vol. 11, no. 4, 2022, doi: 10.21275/SR22409120545.

[9] A. Asraf and B. Kurniawan, *Fisika Dasar untuk Sains dan Teknik Jilid 2: Mekanika Fluida & Termodinamika*. Jakarta, Indonesia: Bumi Aksara, 2021.

[10] A. Mayasri, M. Reza, and M. Nasir, “Identifikasi dan remediasi miskonsepsi dengan pendekatan perubahan konseptual pada materi kesetimbangan kimia,” *Orbital: Jurnal Pendidikan Kimia*, vol. 7, no. 2, 2023, doi: 10.19109/OJPK.V7I2.19810.

[11] E. K. Nisa and M. Habibbulloh, “Development of three tier online test diagnostic of misconception for topic free fall motion,” *Schrödinger: Journal of Physics Education*, vol. 5, no. 2, 2024, doi: 10.37251/SJPE.V5I2.797.

[12] S. Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung, Indonesia: Alfabeta, 2019.

[13] P. A. Wijayanto *et al*., “Three ties tes diagnostic digital berbasis kontekstual konten untuk mengidentifikasi miskonsepsi geografi,” *SAP (Susunan Artikel Pendidikan)*, vol. 9, no. 2, 2024, doi: 10.30998/SAP.V9I2.25057.

[14] A. N. Hakqi, T. Nusantara, and I. S. Rufiana, “Analisis pemahaman konsep pecahan siswa sekolah dasar menggunakan tes diagnostik three tier multiple choice,” *Ideguru: Jurnal Karya Ilmiah Guru*, vol. 10, no. 3, 2025, doi: 10.51169/IDEGURU.V10I3.2321.

[15] S. Sudrajat, “Pengembangan soal three-tier multiple choice berbasis etnomatematika untuk mengukur kemampuan literasi matematika siswa,” *ELIPS: Jurnal Pendidikan Matematika*, vol. 6, no. 1, 2025, doi: 10.47650/ELIPS.V6I1.1758.

[16] S. Arikunto, *Prosedur Penelitian: Suatu Pendekatan Praktik*. Jakarta, Indonesia: Rineka Cipta, 2019.

[17] A. A. Kuserawati, R. Riyadi, and S. Sudiyanto, “Profil tes diagnostik model four tier diagnostic test dalam mengungkap miskonsepsi pada pembelajaran matematika,” *Didaktika Jurnal Kependidikan*, vol. 14, no. 3, 2025, doi: 10.58230/27454312.2454.

[18] P. A. Rararati, H. Nuroso, and A. F. Kurniawan, “Kajian literatur: Penggunaan simulasi PhET dalam pembelajaran fisika,” *LPT: Lontara Physics Today*, vol. 3, no. 2, 2024, doi: 10.26877/LPT.V3I2.21838.

[19] H. Novia and N. J. Fratiwi, *“Ternyata Saya Salah!”: Membangun Pemahaman Fisika melalui Pendekatan eRT-DPA*. Sigufi Artha Nusantara, 2025.

[20] D. A. Rokhim, S. Rahayu, and I. W. Dasna, “Analisis miskonsepsi kimia dan instrumen diagnosisnya: Literatur review,” *Jurnal Inovasi Pendidikan Kimia*, vol. 17, no. 1, 2023, doi: 10.15294/JIPK.V17I1.34245.

[21] D. J. Darojat and Z. Zakirman, “Inovasi pembelajaran fluida dinamis dengan discovery learning dan alat peraga: Dampak pada kreativitas dan pemahaman siswa,” *Wacana Akademika: Majalah Ilmiah Kependidikan*, vol. 8, no. 2, 2024.

[22] G. J. Posner, K. A. Strike, P. W. Hewson, and W. A. Gertzog, “Accommodation of a scientific conception: Toward a theory of conceptual change,” *Science Education*, vol. 66, no. 2, pp. 211–227, 1982, doi: 10.1002/SCE.3730660207.

[23] L. S. Ahmad, D. Utami, T. Z. Naryamastri, and H. Anggito, “Dampak pembelajaran fisika menggunakan alat peraga venturimeter pada materi fluida dinamis,” *Jurnal Ilmiah Pendidikan Profesi Guru*, vol. 7, no. 1, pp. 222–234, 2024.

[24] N. Ramadhani, S. R. Manullang, and V. A. B. Simbolon, “Identifikasi kemampuan siswa dalam pemecahan masalah miskonsepsi pada materi fluida dinamis di tingkat SMA,” *Edufisika: Jurnal Pendidikan Fisika*, vol. 7, no. 2, pp. 196–205, 2022.

[25] S. Metal, S. S. Sitompul, and S. Mursyid, “Penggunaan conceptual change text berbantuan alat peraga untuk meremediasi miskonsepsi materi fluida dinamis di SMA,” *Jurnal Pendidikan dan Pembelajaran Khatulistiwa (JPPK)*, vol. 7, no. 9, 2018.